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# ANALYSIS OF A FEW SONOGRAMS OBTAINED WITH THE AID OF SATELLITES ALOUETTE 1 AND INJUN 3

by

Roger Gendrin
Jacques Vigneron

[FRANCE]



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# ANALYSIS OF A FEW SONOGRAMS OBTAINED WITH THE AID OF SATELLITES ALOUETTE 1 AND INJUN 3 *

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& Jacques Vigneron

## SUMMARY

This study refers to a new type of whistlers received on board of satellites Alouette 1 and Injun 3. These can be interpreted as the result of propagation in the ordinary mode of the original atmospheric impulse, having recourse to certain hypotheses which are discussed.

* * *

INTRODUCTION.- In a recent article, Smith and associates [1] published the sonograms, obtained with the aid of satellites. These convey for frequencies of less than ~500 cps, a double trace, of which the extensions seem to cut each other over the time axis. The first one, nearly vertical, is related to whistlers already detected after small paths aboard satellites [2].- The second, whose dispersion is increased in importance as the frequency rises, offers a horizontal asymptote for a frequency equal to the gyrofrequency of protons in the vicinity of the satellite.

The present authors have suggested two mechanisms for the explanation of such a phenomenon: either an emission, triggered by the flash, or the propagation of the original impulse between ground and the satellite. The last hypothesis is the one we have attempted to verify.

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* Essai d'interprétation de quelques sonogrammes obtenus à l'aide des satellites Alouette 1 et Injun 3.-

The only convenient mode is the ordinary one, which offers an index, rising with the frequency and approaching the infinity for a frequency, equal to the gyrofrequency of positive ions, thus qualitatively justifying the pattern of the sonograms.

FORMULAS.- We consider the case of the quasi-longitudinal approximation. The magnetic field is assumed vertical, its decrease as a function of altitude being that of a dipole field, the absolute values at 1000 and 1800 km being fixed by the gyrofrequencies observed for these altitudes on board of both satellites.

The phase index $n_\varphi$ for the two modes is expressed as a function of medium's parameters (plasma frequency and electron and ion gyrofrequencies) by the formulas of reference [3]. The group index $n_g$ is easily derived therefrom, and thus the transit time.

MODEL ADOPTED.- The electron profile corresponds to that of ref. [4], which is valid for middle latitudes. The formula adopted allows to envision the existence of only a single ion. It cannot be the oxygen, for the latter would give cutoff frequencies that would be too low ($\sim$30 cps). On the other hand, it would be difficult to utilize a model, in which the ionosphere would be constituted only of ions $H^+$.

A compromise would consist in admitting that the propagation, independent from the ordinary mode, takes place only starting at 700 km, height beginning with which the hydrogen ion $H^+$ is the only constituent. The question of energy transfer between ground level and this height will be considered in the course of the discussion.

The Table below gives the electron density and the gyrofrequencies of protons as a function of layers adopted beginning with the 700 km height.

| Height of the layer... | 700-1000 | 1000-1200 | 1200-1400 | 1400-1700 (km) |
|---|---|---|---|---|
| Ionization density ... | $1,5.10^4$ | $10^4$ | $9.10^3$ | $7.10^3$ ($cm^{-3}$) |
| Gyrofrequency (cps)... | 580 | 525 | 485 | 430 (eps) |

RESULTS.- The transit time for the two modes are plotted in Fig. 1, where a good agreement is observed between the experimental curves and the figures obtained.

DISCUSSION. - The calculations are based upon two hypotheses which have to be discussed.

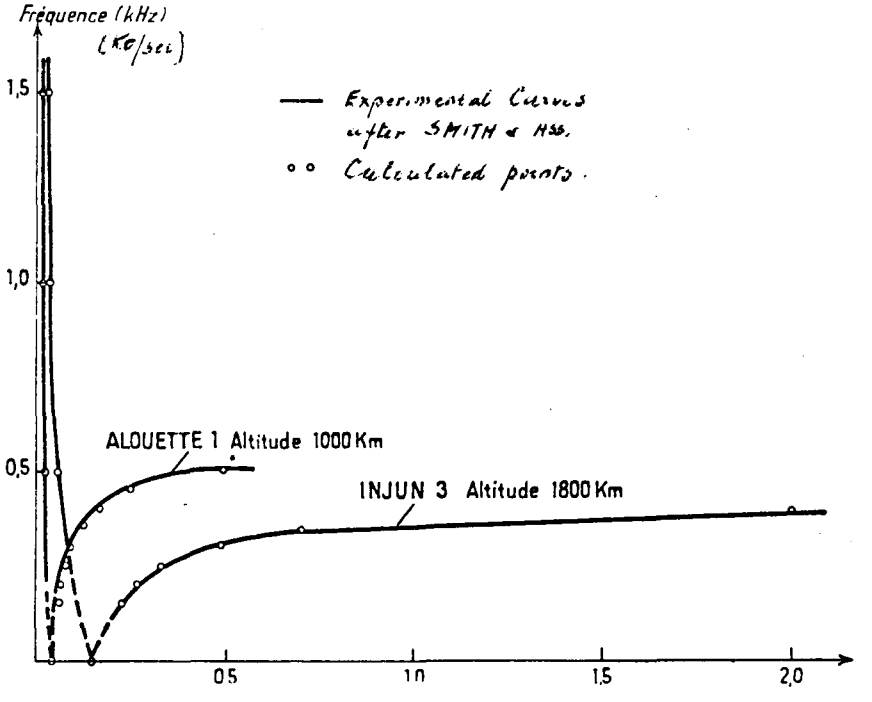


Fig. 1

1) The propagation of uncoupled modes takes place only starting from 700 km.

It is well known that in a medium, where the electron density shows important variations relative to wavelength scale, the two modes are strongly coupled [5]. This coupling can be instrumental in assuring the transfer of energy to an altitude, where the two modes again become independent, as a consequence of the penetration into a region with low electron density gradient.

One could also see in this effect an argument in favor of the theory, whereby whistlers would not be directly engendered by flashes, but by the electrons, which they would project beyond the ionosphere [6].

2) As of that level, the ionosphere is constituted essentially of hydrogen.

It is well known, that at these heights, helium exists in non-negligible proportions [7]. - But the equation utilized can not explain the

transparency of the ionosphere for the frequencies between 200 and 500 cps, even if it is extended to the case of several ions [8]. There too, the full wave theory would allow to extend the calculation in a more real hypothesis of a medium with variable composition.

CONCLUSION.-

Taking these reservations into account, it seems that it is possible to interpret the obtained sonograms by the ordinary propagation mode. The important dispersions at play would lend themselves more easily to the determination of the ion composition than it would be possible to do with the low-frequency part of atmospheric whistlers [9].

*** THE END ***

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on 19 April 1965

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(*Groupe de Recherches Ionosphériques,*
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